

**DRAFT BACTERIA TOTAL MAXIMUM DAILY LOAD (TMDL)
for
Three Bays, Barnstable, Massachusetts
*November 2007 Draft***

**Report Number MA96-TMDL-19
Control Number CN309.0**



| | |
|--------------------------|--|
| Key Feature: | Fecal Coliform Bacteria for Three Bays |
| Location: | EPA Region 1 |
| Land Type: | New England Coastal |
| 303d Listing: | Pathogens: <u>MA96-63</u> - Cotuit Bay from North Bay at Point Isabella oceanward to a line extended along Oyster Harbors Beach, Barnstable <u>MA96-66</u> – North Bay from Fox Island to just south of Bridge Street and separated from Cotuit Bay at a line from Point Isabella southward to the opposite shore (including Dam Pond, Barnstable) <u>MA96-07</u> – Prince Cove including adjacent unnamed cove [referred to as Warren’s Cove] east of Prince Cove to North Bay at Fox Island, Barnstable |
| Data Sources: | University of Massachusetts – Dartmouth/School for Marine Science and Technology; Massachusetts Division of Marine Fisheries; Three Bays Preservation, Inc. |
| Data Mechanism: | Massachusetts Surface Water Quality Standards for Fecal Coliform, Ambient Data, and Best Professional Judgment |
| Monitoring Plan: | Massachusetts Shellfish Sanitation Program; Three Bays Preservation, Inc.; and Watershed Five-Year Cycle |
| Control Measures: | Storm Water Management, Elimination of Boat Discharges, and Investigation for Source Identification |

**Draft Bacteria Total Maximum Daily Load (TMDL)
for
Three Bays, Barnstable, Massachusetts**

Description of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

Three Bays is one of the major estuaries along the south coast of Cape Cod. It is located in Barnstable, Massachusetts and is comprised of the following embayments:

- Cotuit Bay, the southwest embayment, which exchanges water directly with Nantucket Sound (water body segment #MA96-63);
- West Bay, the southeast embayment, which has a tidal inlet to Nantucket Sound (water body segment #MA96-65);
- North Bay, the embayment north of Cotuit and West Bays, which receives tidal waters from both bays through navigable channels (water body segment #MA96-66);
- Prince Cove which is the most northern of the sub-embayments and extends to the west of the Marstons Mills River and includes Warren's Cove to the east of Prince Cove and extends to North Bay at Fox Island (water body segment #MA96-07).

The two predominant land use types in the Three Bays watershed are forestland (36%) and residential (42%). The land area surrounding Prince Cove is the most heavily developed of the Three Bays watershed. Numerous roadways circle all of the bays with tangential residential streets connecting to these roadways.

Cotuit Bay, North Bay and Prince Cove have priority ranking as a component of the Massachusetts Estuary Project and because they exceeded water quality standards for fecal coliform bacteria in historical samplings and analyses. Due to these elevated concentrations of fecal coliform bacteria, all three of these waterbodies are listed on the Massachusetts Integrated List of Waters as Category 5 waters requiring a TMDL. Additionally, the Division of Marine Fisheries has classified certain areas as Conditionally Approved for shell fishing due to high bacteria counts. Currently all of North Bay, including Areas SC 23.2 and SC 23.21, is classified as Conditionally Approved for shell fishing. In Cotuit Bay, Areas SC21.1 and SC21.2 were classified as Conditionally Approved in 1999 and Prince Cove has been classified as "Conditionally Approved" for shell fishing since 1988.

A large bacteria database was constructed to conduct the technical analysis for this project. Among the data sources was a Sanitary Survey in Prince Cove conducted by the Massachusetts Division of Marine Fisheries (DMF) and the Three Bays Preservation, Inc. in 2001. Other existing data that was utilized in the technical analysis included sanitary surveys conducted in North Bay in 1990; a Triennial Sanitary Survey conducted in February of 2000; water quality samples collected from 1985 to 2003; a source identity study using DNA analysis in 2000; and sampling by Massachusetts Estuaries Project at the Marstons Mill River Route 28 culvert in 2002 and 2003.

The technical analysis shows that the most likely sources of fecal coliform bacteria that need to be evaluated are: stormwater inflows from paved areas; boat discharges in the cove; waterfowl/wildlife within Prince and the adjacent Warren's Cove with their associated wetlands; and transport of fecal coliform via the Marstons Mills River into the Coves via tidal exchange.

More detailed information on the description of Three Bays, the pollutant of concern (fecal coliform bacteria), pollutant sources and priority ranking is presented in the accompanying technical report entitled "Basis for Development of Total Maximum Daily Load of Bacteria – Prince Cove/Three Bays Watershed, Town of Barnstable", dated August 2005, and authored by University of Massachusetts Dartmouth – School of Marine Science and Technology (SMAST). This information can be found in the Executive Summary and Sections II, III and V of the technical report.

Description of the Applicable Water Quality Standards and Numeric Water Quality Criteria

The Massachusetts Water Quality Standards call for all water classes to be good or excellent "... habitat for fish, other aquatic life and wildlife ...". Coastal waters, such as Three Bays, that are classified as SA waters shall have a fecal coliform bacteria concentration not exceeding a geometric mean of 14 organisms per 100 mL, nor shall more than 10 percent of the samples exceed 43 organisms per 100 mL. The Massachusetts Water Quality Standards for fecal coliform were revised on 12/29/06 to state that not more than 10% of the samples exceed a Most Probable Number of 28 per 100 mL.

For the protection of shellfish resources, fecal coliform bacteria is the pathogenic indicator utilized by the Commonwealth of Massachusetts as the measure to determine if a coastal marine water body is in compliance with bacteria based Water Quality Standards. The goal of this TMDL report will be to decrease or eliminate fecal coliform bacterial contamination or determine that it is not wastewater derived (i.e. from wildlife) in order to protect human health and return these waters to their most beneficial use as a shellfish resource.

Total Maximum Daily Load Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent approved impairment list, *Final Massachusetts Year 2004 Integrated List of Waters*, identifies Cotuit Bay, North Bay and Prince Cove for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and nonpoint pollution sources are accounted for in a TMDL analysis. EPA regulations require that point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a wasteload allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Nonpoint sources of pollution (and point sources not subject to NPDES permits) receive load allocations (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In the case of stormwater, it is often difficult to identify and distinguish between point source discharges that are subject to NPDES regulation and those that are not. Therefore, EPA has stated that it is permissible to include all point source stormwater discharges in the WLA portion of the TMDL. MassDEP has taken this approach. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{Margin of Safety}$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future nonpoint source (and point sources not subject to NPDES permits).

This TMDL is explained using an alternative standards-based approach, which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as when an equation is used.

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 C.F.R. § 130.2(i)). Typically, TMDLs are expressed as total maximum daily loads. Expressing the bacteria TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load which is dependent on flow conditions. Therefore the magnitude of the bacteria load that is allowable within water quality standards will vary as flow rates change. For example, a very high number of indicator bacteria are allowable if the volume of water that transports the bacteria is also high provided water quality standards are still met. Conversely, a relatively low number of bacteria may exceed the water quality standards if flow rates are low. In conformance with the requirements that maximum daily loads be explicit, MassDEP has calculated these loads which are scaled to runoff volumes as noted in Figure 1. By assuming that surfaces within 200 feet of the shoreline discharge directly to the waterbody, the runoff volume for the Three Bays watershed has been estimated at 472 acres. MassDEP believes it is appropriate to express indicator bacterial TMDLs proportional to flow. Because the water quality standard is also expressed in terms of the concentration of organisms per 100 mL, the acceptable in-stream daily load or TMDL is the product of that flow and the criterion, which is the same approach used for any pollutant with a numerical criterion. In the case of embayments, runoff is the flow that is being used to determine the maximum daily load. In recognition of the fact that bacteria loads are flow dependent, varying flow rather than a single value is used to calculate the TMDL as reflected in the following equation:

$$\text{TMDL} = \text{State Standard} \times Q_R = WLA_{(p1)} + LA_{(n1)} + WLA_{(p2)} + \text{etc.}$$

Where:

$WLA_{(p1)}$ = allowable concentration for point source category (1)

$LA_{(n1)}$ = allowable concentration for nonpoint source category (1)

$WLA_{(p2)}$ = allowable concentration for point source category (2) etc.

Q_R = runoff flow on any given day.

Wasteload Allocations (WLAs) and Load Allocations (LAs)

Although there are no permitted discharges of fecal coliform to Prince Cove, direct stormwater discharges from storm drainage systems occur. Discharges from stormwater conveyances (including pipes, channels, roads with drainage systems and municipal streets) are by definition point sources and are subject to the requirements of NPDES Phase II stormwater permits. Therefore, a WLA set equal to the fecal coliform standard will be assigned to the portion of the stormwater that discharges to surface waters via stormwater conveyances.

WLAs and LAs to Prince Cove have been identified for all suspected source categories including both dry and wet weather sources. Establishing WLAs and LAs that only address dry weather bacteria sources would not ensure attainment of standards because there is a noteworthy contribution of wet weather bacteria sources to fecal coliform criteria exceedences. The most likely sources of fecal coliform bacteria that were identified are stormwater inflows, waterfowl/wildlife and boat discharges.

Table 1 presents the fecal coliform bacteria WLAs and LAs for the various potential source categories. Source categories representing discharges of stormwater from distinct point sources (stormwater conveyances) are set equal to the fecal coliform standard for SA waters in order to ensure that standards for shellfish harvesting can be met.

| Surface Water Classification | Bacteria Source Category | Waste Load Allocation (Organisms per 100 mL) | Load Allocation (Organisms per 100 mL) |
|------------------------------|-----------------------------------|---|---|
| SA | Failing Septic Systems | N/A | 0 |
| SA | Stormwater Runoff Phase II | Geometric Mean ≤ 14 Nor shall 10% of samples be ≥ 28 | N/A |
| SA | Nonpoint Source Stormwater Runoff | N/A | Geometric Mean ≤ 14 Nor shall 10% of samples be ≥ 28 |
| SA | Wildlife* | N/A | N/A |
| SA | Boat Discharges | 0 | N/A |

Table 1. Fecal Coliform Wasteload Allocations (WLAs) and Load Allocations (LAs) for Prince Cove

*Given that sources of fecal coliform from wildlife is naturally occurring no allocation has been assigned.

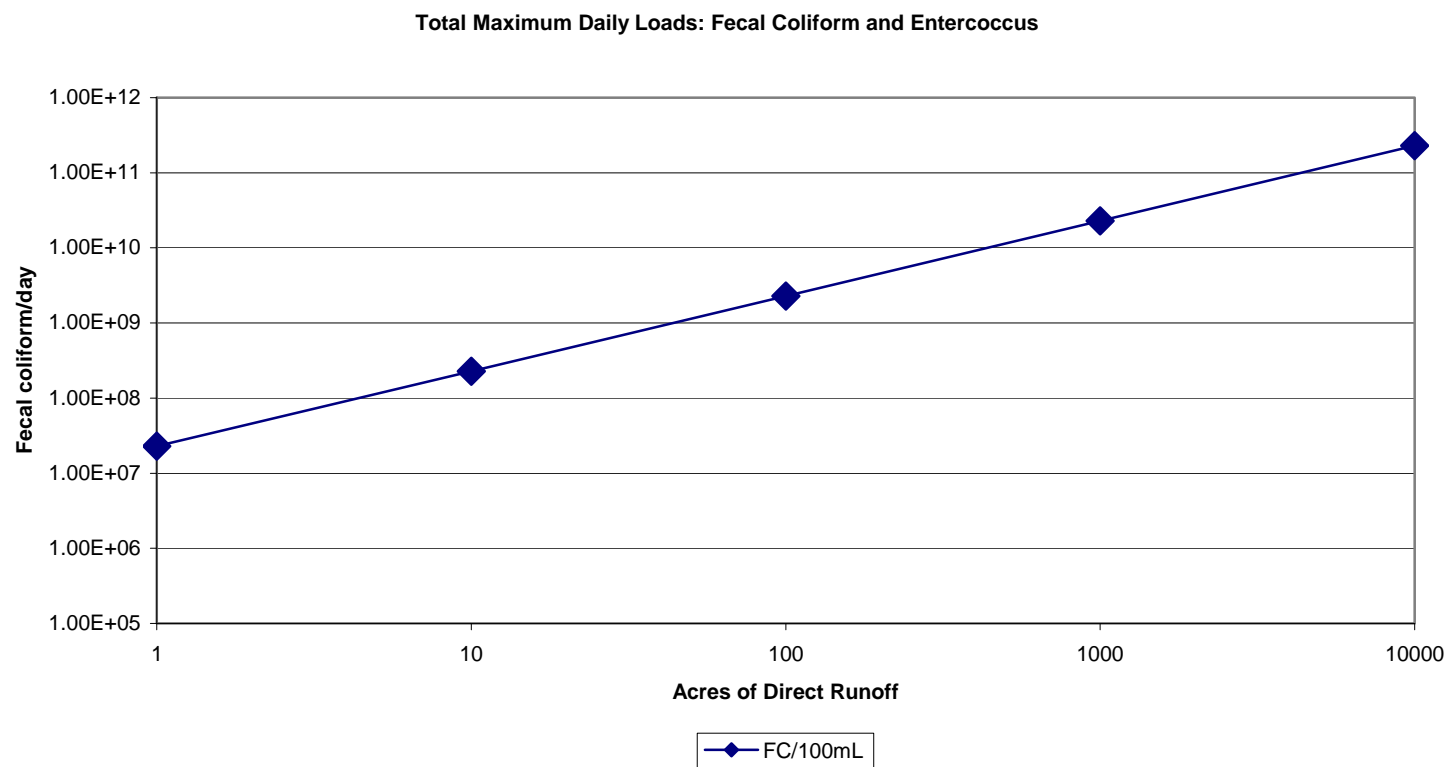


Figure 1. Fecal Coliform bacteria concentrations and runoff volumes.

The TMDL should provide a discussion of the magnitude of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For illicit sources such as failing septic systems or illegal tie-ins to the storm drains, the goal is complete elimination (100% reduction). Source categories representing discharges of stormwater from distinct point sources are set equal to the fecal coliform standard for SA waters in order to ensure that standards for shellfish harvesting can be met in the waterbody.

Overall reductions needed to attain water quality standards are estimated using ambient fecal coliform data. Using ambient data is beneficial because it provides a realistic estimate of existing conditions and the magnitude of cumulative loading to the surface waters. Reductions are calculated using data that was collected in the summer (May through October) and winter (November through April) during both wet and dry weather conditions. Less than 0.25 inches of precipitation was considered to be a dry weather sample and greater than 0.25 inches was a wet weather sample. Percent reductions to attain the water quality standard of 14 organisms per 100 mL are presented in Tables 2, 4, 6 and 8. Tables 3, 5, 7 and 9 list the 90% observation and percent reductions necessary to attain the water quality standard which states that no more than 10% of the samples exceed 28 organisms per 100 mL. The 90% observation indicates that within the range of data collected for each station, 90% of the samples collected at that station fall below the stated value. As an example, for data collected during the 1985-1995 summer station at Station #1 for Prince Cove, 90% of the samples had a concentration below 128 per 100/mL (Table 8). To meet the water quality standard, the 90% observation would have to be reduced to 28 organisms per 100 mL, therefore, a 78.1% reduction is necessary at that station.

Reductions Needed to Attain Water Quality Standards

Division of Marine Fisheries Data

Data on fecal coliform bacteria that was collected by DMF were compiled and analyzed for the 1985-1995 and 1996-2003 time periods. As can be seen in Tables 2 and 4, all the summer and winter fecal coliform geometric means during both dry and wet weather in West and Cotuit Bays were below the water quality standard of 14 CFU/100 mL. More than 10% of the samples collected in West Bay met the water quality standard of 28 CFU/100 mL and no reductions are needed for the 1996-2003 period (Table 3). Table 5 indicates that in Cotuit Bay during the 1985-1995 period, reductions of up to 78.1% are required in order to meet this standard in the both the summer and winter. Subsequent sampling in the more recent 1996-2003 time period, however, indicated elevated fecal coliform counts only at Stations# 5 and 11 in the summer both of which require a 44% reduction.

Table 6 indicates that the summer data for Prince and Warren's Coves is representative of the worst-case scenario requiring the greatest reduction in bacterial levels. Reductions in fecal coliform of up to 72.5% are required in Prince and Warren's Coves throughout the summer during both wet and dry weather in order to meet the water quality standard of 14 CFU/100 mL. In contrast, fecal coliform counts throughout the winter at both coves consistently met this standard. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in Prince and Warren's Coves and the 1996-2003 data indicate that reductions of up to 45.1% are required in both the summer and winter (Table 7).

In North Bay the summer wet geomeans exceeded the water quality standard of 14 CFU/100 mL at Stations 8 and 9 requiring reductions of 53.3 and 17.6% respectively (Table 6). Winter fecal coliform levels were significantly lower than the summer levels with none of the winter geometric means exceeding the water quality standard of 14 CFU/100 mL. In North Bay, more than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL at several stations during the summer with reductions of up to 78.1% needed during the 1985-1995 period (Table 7). For the 1996-2003 period the stations that were sampled met this water quality standard.

At station SM, which is the Route 28 culvert on the Marstons Mills River, wet geomeans exceeded the standard in both summer and winter requiring reductions of up to 92.9% and 48.1%

respectively. More than 10% of the samples exceed the water quality standard of 28 CFU/100 mL during both the summer and winter with reductions between 72 and 93.9% necessary to attain this water quality standard (Table 7).

Three Bays Preservation Inc. Data

As can be seen in Tables 8 and 9, data collected by the Three Bays Preservation Inc. was consistent with the findings of the DMF dataset both in the coliform levels and the spatial and seasonal pattern of bacterial contamination.

There were no exceedences in West Bay for the 14 organisms per 100 mL water quality standard and 10% of the samples did not exceed the water quality standard of 28 CFU/100 mL.

Prince Cove requires no reductions in the winter and up to an 83.3% reduction in the summer to meet the 14 organisms per 100 mL water quality standard. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL during the summer requiring reductions of up to 93.2%. This water quality standard was met during winter weather.

In Warren's Cove in order to meet the 14 organisms per 100 mL water quality standard a 97.3% reduction is required in the summer and a 65% reduction in the winter. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in the summer with reductions of 97.6% required.

The 14 organisms per 100 mL water quality standard was met in North Bay with the exception of the summer wet data requiring a reduction up to 33.3% (Table 8). More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in the summer requiring reductions up to 65% (Table 9).

The Marstons Mills River stations exceeded the 14 organisms per 100 mL standard in both the summer and winter during wet and dry conditions requiring reductions of up to 80.8% in the summer and 94.2% in the winter. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL with reductions of 80% required in the summer.

Data Conclusions

In summary, the data indicates that West and Cotuit Bays contain low concentrations of fecal coliform bacteria while levels of fecal coliform bacteria in excess of the water quality standards frequently occur in Prince Cove, Warren's Cove and the tidal channel to North Bay. Analysis of the bacterial loads in the Marstons Mills River indicates that the river is an important source of bacterial contamination.

| WEST BAY FECAL COLIFORM | | | | | | | | |
|-------------------------|----------------------------------|----------------------------------|----------------------------------|------------------------------|------------------------------|----------------------------------|------------------------------|------------------------------|
| | 1985 – 1995 | | 1996-2003 | | | | | |
| | SUMMER | WINTER | SUMMER | | | WINTER | | |
| Station# | Overall Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) |
| 1 | 3/(0%) | 4/(0%) | 2/(0%) | 2/(0%) | 2/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |
| 2 | 4/(0%) | 2/(0%) | 3/(0%) | 4/(0%) | 2/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |
| 3 | 8/(0%) | 2/(0%) | 4/(0%) | 6/(0%) | 3/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |
| 4 | 10/(0%) | 2/(0%) | 4/(0%) | 7/(0%) | 3/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |
| 5 | 4/(0%) | 1/(0%) | 3/(0%) | 4/(0%) | 3/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |
| 6 | 6/(0%) | *2/(0%) | ND | ND | ND | ND | ND | ND |
| 7 | 3/(0%) | 2/(0%) | 3/(0%) | 3/(0%) | 3/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |

Table 2. Estimates of fecal coliform loading reductions to West Bay necessary to meet the 14 organisms per 100 mL Water Quality Standard.

*Too few data for accurate geometric mean (less than five samples collected)

ND= No Data

| WEST BAY FECAL COLIFORM | | | | |
|-------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| | 1985 – 1995 | | 1996-2003 | |
| | SUMMER | WINTER | SUMMER | WINTER |
| Station# | 90% Observation /(%Reduction) | 90% Observation/ (%Reduction) | 90% Observation/ (%Reduction) | 90% Observation/ (%Reduction) |
| 1 | 11/(0%) | 30/(6.7%) | 4/(0%) | 2/(0%) |
| 2 | 11/(0%) | 14/(0%) | 8/(0%) | 2/(0%) |
| 3 | 41/(31.7%) | 3.6/(0%) | 8/(0%) | 1.9/(0%) |
| 4 | 41/(31.7%) | 3.6/(0%) | 14/(0%) | 2/(0%) |
| 5 | 18/(0%) | 1.9/(0%) | 8/(0%) | 4/(0%) |
| 6 | 23/(0%) | 1.9/(0%) | ND | ND |
| 7 | 11/(0%) | 1.9/(0%) | 8/(0%) | 2/(0%) |

Table 3. 90% observation and estimates of fecal coliform loading reductions to West Bay necessary to meet the 28 organisms per 100 mL Water Quality Standard.

ND= No Data

| COTUIT BAY FECAL COLIFORM | | | | | | | | |
|---------------------------|----------------------------------|----------------------------------|----------------------------------|------------------------------|------------------------------|----------------------------------|------------------------------|------------------------------|
| | 1985 – 1995 | | 1996-2003 | | | | | |
| | SUMMER | WINTER | SUMMER | | | WINTER | | |
| Station# | Overall Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) |
| 1 | 4/(0%) | 4/(0%) | 2/(0%) | 2/(0%) | 2/(0%) | 3/(0%) | 3/(0%) | 2/(0%) |
| 2 | 3/(0%) | 2/(0%) | 3/(0%) | 3/(0%) | 4/(0%) | 3/(0%) | 3/(0%) | 2/(0%) |
| 3 | 2/(0%) | 2/(0%) | ND | ND | ND | ND | ND | ND |
| 3A | 8/(0%) | 2/(0%) | ND | ND | ND | **2/(0%) | ND | 2/(0%) |
| 4 | 4/(0%) | 2/(0%) | 5/(0%) | 5/(0%) | 5/(0%) | 2/(0%) | 2/(0%) | 2/(0%) |
| 5 | 6/(0%) | 2/(0%) | 12/(0%) | 13/(0%) | 12/(0%) | 3/(0%) | 3/(0%) | 3/(0%) |
| 6 | 3/(0%) | 1/(0%) | **8/(0%) | ND | 8/(0%) | **2/(0%) | 2/(0%) | ND |
| 6B | 10/(0%) | 9/(0%) | 3/(0%) | 4/(0%) | 2/(0%) | 3/(0%) | 4/(0%) | 2/(0%) |
| 7 | 3/(0%) | 2/(0%) | 2/(0%) | 3/(0%) | 2/(0%) | 3/(0%) | 2/(0%) | 3/(0%) |
| 8 | 7/(0%) | 5/(0%) | 2/(0%) | 3/(0%) | 2/(0%) | 3/(0%) | 5/(0%) | 2/(0%) |
| 9 | 6/(0%) | 5/(0%) | ND | ND | ND | *2/(0%) | 2/(0%) | 2/(0%) |
| 9A | ND | ND | ND | ND | ND | ND | ND | ND |
| 10 | *4/(0%) | *3/(0%) | ND | ND | ND | ND | ND | ND |
| 11 | ND | ND | 9/(0%) | *5/(0%) | 6/(0%) | 3/(0%) | 2/(0%) | 3/(0%) |

Table 4. Estimates of fecal coliform loading reductions to Cotuit Bay necessary to meet the 14 organisms per 100 mL Water Quality Standard.

*Too few data for accurate geometric mean (less than five samples collected)

** Value represented is one data point

ND= No Data

| COTUIT BAY FECAL COLIFORM | | | | |
|---------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | 1985 – 1995 | | 1996-2003 | |
| | SUMMER | WINTER | SUMMER | WINTER |
| Station# | Overall Geomean/(%Reduction) | Overall Geomean/(%Reduction) | Overall Geomean/(%Reduction) | Overall Geomean/(%Reduction) |
| 1 | 11/(0%) | 36/(22.2%) | 4/(0%) | 8/(0%) |
| 2 | 14/(0%) | 23/(0%) | 8/(0%) | 6/(0%) |
| 3 | 5.8/(0%) | 5.8/(0%) | ND | ND |
| 3A | 128/(78.1%) | 5.8/(0%) | ND | ** |
| 4 | 14/(0%) | 5.8/(0%) | 22/(0%) | 2/(0%) |
| 5 | 23/(0%) | 2/(0%) | 50/(44.0%) | 8/(0%) |
| 6 | 8.2/(0%) | 1.7/(0%) | ** | ** |
| 6B | 128/(78.1%) | 30/(6.7%) | 8/(0%) | 8/(0%) |
| 7 | 5.8/(0%) | 5.8/(0%) | 4/(0%) | 8/(0%) |
| 8 | 41/(31.7%) | 128/(78.1%) | 6/(0%) | 14/(0%) |
| 9 | 23/(0%) | 64/(56.3%) | ND | 2/(0%) |
| 9A | ND | 8.2/(0%) | ND | ND |
| 10 | 9.1/(0%) | 2/(0%) | ND | ND |
| 11 | ND | ND | 50/(44.0%) | 6/(0%) |

Table 5. 90% observation and estimates of fecal coliform loading reductions to Cotuit Bay necessary to meet the 28 organisms per 100 mL Water Quality Standard.

** Value represented is one data point

ND= No Data

| NORTH BAY/PRINCE COVE FECAL COLIFORM | | | | | | | | | |
|--------------------------------------|-----------------|----------------------------------|----------------------------------|----------------------------------|------------------------------|------------------------------|----------------------------------|------------------------------|------------------------------|
| | | 1985 – 1995 | | 1996-2003 | | | | | |
| STATION | | SUMMER | WINTER | SUMMER | | | WINTER | | |
| # | Location | Overall Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) |
| 1 | Prince Cove | 14 / (0%) | 2 / (0%) | 22 / (36.4%) | *14 / (0%) | *27 / (48.1%) | 3 / (0%) | 4 / (0%) | 3 / (0%) |
| 1A | Prince Cove | 19 / (26.3%) | 3 / (0%) | 21 / (33.3%) | *43 / (67.4%) | *15 / (6.6%) | 3 / (0%) | 3 / (0%) | 3 / (0%) |
| 1B | Warren's Cove | 33 / (57.5%) | 4 / (0%) | 45 / (68.8%) | *51 / (72.5%) | *42 / (66.6%) | 8 / (0%) | 8 / (0%) | 7 / (0%) |
| 2 | Warren's Cove | 50 / (72%) | 8 / (0%) | 48 / (70.8%) | *43 / (67.4%) | *50 / (72%) | 10 / (0%) | 11 / (0%) | 9 / (0%) |
| 3 | Prince Cove | 51 / (72.5%) | 5 / (0%) | 43 / (67.4%) | *51 / (72.5%) | *40 / (65%) | 8 / (0%) | 9 / (0%) | 7 / (0%) |
| 3A | Prince Cove | *31 / (54.8%) | 4 / (0%) | ND | ND | ND | ND | ND | ND |
| 4 | North Bay | 19 / (26.3%) | 2 / (0%) | 6 / (0%) | *8 / (0%) | *6 / (0%) | 3 / (0%) | 3 / (0%) | 3 / (0%) |
| 4A | North Bay | ND | *6 / (0%) | ND | ND | ND | ND | ND | ND |
| 5 | North Bay | 11 / (0%) | 2 / (0%) | ND | ND | ND | **2 / (0%) | **2 / (0%) | ND |
| 5S | North Bay | ND | **4 / (0%) | ND | ND | ND | ND | ND | ND |
| 6 | North Bay | 5 / (0%) | 2 / (0%) | 3 / (0%) | *3 / (0%) | *3 / (0%) | 2 / (0%) | 3 / (0%) | 2 / (0%) |
| 6S | North Bay | ND | *6 / (0%) | ND | ND | ND | ND | ND | ND |
| 7 | North Bay | 5 / (0%) | 2 / (0%) | 3 / (0%) | *7 / (0%) | *2 / (0%) | 3 / (0%) | 3 / (0%) | 2 / (0%) |
| 7B | North Bay | ND | *1 / (0%) | ND | ND | ND | ND | ND | ND |
| 8 | North Bay | 15 / (6.6%) | 2 / (0%) | 11 / (0%) | *30 / (53.3%) | *6 / (0%) | 3 / (0%) | 3 / (0%) | 3 / (0%) |
| 8B | North Bay | ND | *2 / (0%) | ND | ND | ND | ND | ND | ND |
| 9 | North Bay | 10 / (0%) | 2 / (0%) | 5 / (0%) | *17 / (17.6%) | *3 / (0%) | 3 / (0%) | 3 / (0%) | 2 / (0%) |
| 9B | North Bay | ND | 2 / (0%) | ND | ND | ND | ND | ND | ND |
| SM ¹ | Rte. 28 Culvert | ND | ND | 107 / (86.9%) | 197 / (92.9%) | **10 / (0%) | 21 / (33.3%) | 27 / (48.1%) | 5 / (0%) |

Table 6. Estimates of fecal coliform loading reductions to North Bay/Prince Cove necessary to meet the 14 organisms per 100 mL Water Quality Standard.

*Too few data for accurate geometric mean (less than five samples collected)

** Value represented is one data point

¹Data collected is for the 2002-2003 period only

ND= No Data

| NORTH BAY/PRINCE COVE FECAL COLIFORM | | | | | |
|--------------------------------------|------------------|----------------------------------|----------------------------------|----------------------------------|-----------------------------------|
| | | 1985 – 1995 | | 1996 - 2003 | |
| STATION | | SUMMER | WINTER | SUMMER | WINTER |
| # | Location | 90% Observation/ (%Reduction) | 90% Observation/ (%Reduction) | 90% Observation/ (%Reduction) | 90% Observation / (%Reduction) |
| 1 | Prince Cove | 128 / (78.1%) | 6 / (0%) | 50 / (44.0%) | 11 / (0%) |
| 1A | Prince Cove | 30 / (6.7%) | 14 / (0%) | 36 / (22.2%) | 14 / (0%) |
| 1B | Warren's Cove | 65 / (56.9%) | 14 / (0%) | 51 / (45.1%) | 51 / (45.1%) |
| 2 | Warren's Cove | 128 / (78.1%) | 64 / (56.3%) | 51 / (45.1%) | 51 / (45.1%) |
| 3 | Prince Cove | 128 / (78.1%) | 30 / (6.7%) | 51 / (45.1%) | 51 / (45.1%) |
| 3A | Prince Cove | 128 / (78.1%) | 14 / (0%) | ND | ND |
| 4 | North Bay | 128 / (78.1%) | 14 / (0%) | 8 / (0%) | 11 / (0%) |
| 4A | North Bay | ND | 5.8 / (0%) | ND | ND |
| 5 | North Bay | 128 / (78.1%) | 8.2 / (0%) | ND | ** |
| 5S | North Bay | ND | ** | ND | ND |
| 6 | North Bay | 18 / (0%) | 5.8 / (0%) | 6 / (0%) | 6 / (0%) |
| 6S | North Bay | ND | 18 / (0%) | ND | ND |
| 7 | North Bay | 23 / (0%) | 3.6 / (0%) | 1.9 / (0%) | 6 / (0%) |
| 7B | North Bay | ND | 1.7 / (0%) | ND | ND |
| 8 | North Bay | 128 / (78.1%) | 8.2 / (0%) | 18 / (0%) | 8 / (0%) |
| 8B | North Bay | ND | 11 / (0%) | ND | ND |
| 9 | North Bay | 128 / (78.1%) | 30 / (6.7%) | 8 / (0%) | 6 / (0%) |
| 9B | North Bay | ND | 5.8 / (0%) | ND | ND |
| SM ¹ | Route 28 Culvert | ND | ND | 460 / (93.9%) | <100 / (72%) |

Table 7. 90% observation and estimates of fecal coliform loading reductions to North Bay/Prince Cove necessary to meet the 28 organisms per 100 mL Water Quality Standard.

** Value represented is one data point

ND= No Data

¹Data collected is for the 2002-2003 period only

| THREE BAYS FECAL COLIFORM | | | | | | | |
|---------------------------|----------------------|----------------------------------|------------------------------|------------------------------|----------------------------------|------------------------------|------------------------------|
| | | 1999 - 2003 | | | | | |
| | | SUMMER | | | WINTER | | |
| STATION # | | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) | Overall Geomean/ (%Reduction) | Wet Geomean/ (%Reduction) | Dry Geomean/ (%Reduction) |
| 1 | Marstons Mills River | 71 / (80.3%) | 73 / (80.8%) | 70 / (80%) | 34 / (58.8%) | **240 / (94.2%) | *21 / (33.3%) |
| 2 | Prince Cove | 37 / (62.2%) | 75 / (81.3%) | 29 / (51.7%) | 6 / (0%) | **5 / (0%) | *6 / (0%) |
| 3 | Prince Cove | 56 / (75%) | 84 / (83.3%) | 48 / (70.8%) | *7 / (0%) | **5 / (0%) | **10 / (0%) |
| 4 | Warren's Cove | 212 / (93.4%) | 515 / (97.3%) | 156 / (91.0%) | *35 / (60%) | **30 / (53.3%) | **40 / (65%) |
| 5 | North Bay | 14 / (0%) | 21 / (33.3%) | 12 / (0%) | 5 / (0%) | **5 / (0%) | *5 / (0%) |
| 6 | North Bay | 12 / (0%) | 18 / (22.2%) | 11 / (0%) | *5 / (0%) | ND | *5 / (0%) |
| 7 | North Bay | 11 / (0%) | 16 / (12.5%) | 9 / (0%) | **5 / (0%) | ND | **5 / (0%) |
| 8 | West Bay | 6 / (0%) | 5 / (0%) | 7 / (0%) | *5 / (0%) | **5 / (0%) | **5 / (0%) |
| 9 | West Bay | 6 / (0%) | 7 / (0%) | 6 / (0%) | 5 / (0%) | **5 / (0%) | *5 / (0%) |
| 13 | Cotuit Bay | 6 / (0%) | 6 / (0%) | 6 / (0%) | 5 / (0%) | **5 / (0%) | *5 / (0%) |
| 15 | West Bay | 6 / (0%) | 5 / (0%) | 7 / (0%) | **5 / (0%) | ND | **5 / (0%) |
| 16 | West Bay | 6 / (0%) | 8 / (0%) | 5 / (0%) | **5 / (0%) | ND | **5 / (0%) |

Table 8. Estimates of fecal coliform loading reductions to Three Bays necessary to meet the 14 organisms per 100 mL Water Quality Standard.

*Too few data for accurate geometric mean (less than five samples collected)

** Value represented is one data point

ND= No Data

| THREE BAYS FECAL COLIFORM | | | |
|---------------------------|----------------------|------------------------------|------------------------------|
| 1999 - 2003 | | | |
| | | SUMMER | WINTER |
| STATION # | | 90% Observation/(%Reduction) | 90% Observation/(%Reduction) |
| 1 | Marstons Mills River | 140 / (80%) | 40 / (30%) |
| 2 | Prince Cove | 190 / (85.3%) | <10 / (0%) |
| 3 | Prince Cove | 410 / (93.2%) | 10 / (0%) |
| 4 | Warren's Cove | 1160 / (97.6%) | 40 / (30%) |
| 5 | North Bay | 80 / (65%) | <10 / (0%) |
| 6 | North Bay | 40 / (30%) | <10 / (0%) |
| 7 | North Bay | 40 / (30%) | ** |
| 8 | West Bay | 10 / (0%) | <10 / (0%) |
| 9 | West Bay | 10 / (0%) | <10 / (0%) |
| 13 | Cotuit Bay | 10 / (0%) | <10 / (0%) |
| 15 | West Bay | 10 / (0%) | ** |
| 16 | West Bay | <10 / (0%) | ** |

Table 9. 90% observation and estimates of fecal coliform loading reductions to Three Bays necessary to meet the 28 organisms per 100 mL Water Quality Standard.

** Value represented is one data point

ND= No Data

Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. This TMDL recognizes that the concentration of bacteria, the pollutant of concern, is greater during the summer season, however, this TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds or intakes for water supplies and in areas when primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

Monitoring Plan

Long term monitoring at established ambient sampling stations will be important to assess the effectiveness of efforts to reduce bacteria and determine if water quality standards are being attained. The Massachusetts Division of Marine Fisheries has a well established and effective shellfish monitoring program that provides quality assured data which can be used to assess water quality standards attainment. Each growing area must have a complete sanitary survey every twelve years, a triennial evaluation every three years and an annual review in order to maintain a shellfish harvesting classification. The National Shellfish Sanitation Program established minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring including the identification of specific sources and the assessment of the effectiveness of controls and attainment of standards.

Efforts by groups to monitor on a frequent basis as was demonstrated by the Three Bays Preservation, Inc. should continue. MassDEP will work with any and all such groups to ensure all data are compatible and comparable. The DMF data in combination with the Three Bays Preservation, Inc. data will be used to evaluate progress and will serve as a baseline to evaluate future controls resulting from implementation activities.

TMDL Implementation

The objective of this TMDL is to specify reductions in bacterial pollutant loads so that water quality standards for aquatic life and shellfish harvesting can be met. The detailed discussion for this topic is presented in the Executive Summary and Section VI of the accompanying technical report. The following presents a summary of the specific measures that should be taken:

- The data indicates that the Marstons Mills River is one of the main contributors of the bacterial contamination in Prince Cove. A sanitary survey should be undertaken by the town of Barnstable to identify the bacterial sources to the Marstons Mills River.
- The Massachusetts Highway Department should determine the Route 28 roadway drainage area discharging to the Marstons Mills River and install best management structures and/or operational practices to the maximum extent practicable and at a

minimum, be designed to meet the water quality standard for bacteria in SA waters. Given this is a waterway with an approved TMDL, the MHD must meet the requirements of EPA's NPDES General Permit for Stormwater Discharges from Small MS4s (Phase II), Part I D(1-4), as it pertains to approved TMDLs.

- In 2000 the Three Bays Preservation, Inc. conducted a fecal coliform source identity study throughout the Three Bays System. As a part of this study, DNA testing was done which showed most bacterial contamination comes from wildlife sources, however, human sources to Prince and Warren's Coves are indicated. The Board of Health should continue to focus on finding the sources of bacteria with a "human DNA" signature within these coves. The potential for an isolated failing on-site septic system should be a part of this investigation.
- In Prince Cove higher levels of bacteria are found at the well-flushed entrance and lower levels are present at the more poorly flushed upper station indicating a source near the entrance. The tidal inflows from Warren's Cove may be one of the potential sources. The extent to which bacterial contaminants from Warren's Cove contribute to the contamination in Prince Cove should be quantified by the Town of Barnstable.
- The Three Bays System recently received designation as a "No Discharge Zone" making direct discharge of wastewater from boats illegal. However, these discharges may still occur periodically during the summer. The Town of Barnstable should institute a sampling program that evaluates the bacterial impacts of greywater discharges and illegal blackwater discharges from moored boats particularly in Prince Cove.
- The land areas surrounding Prince Cove are the most heavily developed in the entire Three Bays watershed. There are numerous roadways circling all of the bays with tangential residential roads connecting to those. Stormwater runoff from roads is a likely source of contamination in some regions. The Town of Barnstable should continue to work toward compliance with its Stormwater Management Program established under the NPDES Phase II Stormwater Program to implement the six minimum control measures.
- Any bacterial testing that is done to determine sources of contamination should consider analytical testing to differentiate anthropogenic versus non-anthropogenic sources to rule out waterfowl/wildlife as the source.
- The salt marsh at Station 8 in the southeast quadrant of North Bay should be investigated by the Board of Health for human sources of fecal coliforms.

Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include a history of voluntary actions taken by local officials, citizen organizations and the general public; the availability of financial incentives; programs for pollution control at the local, state and federal level; and compliance with current regulations. Financial incentives include federal monies available under the 319 NPS program and the 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MassDEP and the USEPA. MassDEP will work with the Town to assist in the development of projects under these grant programs.

Additional financial incentives include state income tax credits for Title 5 upgrades and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

Stormwater NPDES permit coverage will address discharges from municipal owned stormwater drainage systems. Existing regulations that will be effective in controlling nonpoint discharges include the state's Wetlands Protection Act and Rivers Protection Act, Title 5 regulations for septic systems and various local regulations including zoning regulations.

Public Participation
To be completed.